Calculators may be used in this examination provided they are not capable of being used to store alphabetical information other than hexadecimal numbers

UNIVERSITY OF BIRMINGHAM

School of Computer Science

Operating Systems and Systems Programming

Mock Exam March 2024

Time allowed: 2 hours

[Answer all questions]

Turn Over

Note

Answer ALL questions. Each question will be marked out of 20. The paper will be marked out of 80, which will be rescaled to a mark out of 100.

Question 1

(a) What is pointer arithmetic? Why can it lead to program crashes? **[6 marks]**

(b) How can buffer overflow arise in C? Why is it so dangerous? **[6 marks]**

(c) Consider the following program fragment:

```
 1  struct List_t {
 2      char *elem;
 3      struct List_t *next;
 4  };
 5
 6  int main (int argc, char **argv){
 7      int i = 0;
 8      char *arg;
 9      struct List_t *head = NULL, *tmp;
10      while (i < argc) {
11          sprintf (arg, "Argument %d is %s\n", i, argv[i]);
12          head->elem =arg;
13          head->next = tmp;
14          tmp = head;
15          i++;
16      }
17      return 0;
18  }
```

The intention is that head points to a list containing the arguments supplied to the program. The program compiles correctly, but contains errors including but not restricted to memory management and handling of lists. Identify the errors and correct them. **[8 marks]**

Question 2

The question is about concurrent programming.

(a) In the following program, the main thread creates four peer threads and passes a pointer to the loop variable to each one. Each peer thread prints a message containing the loop variable.

```
 1 #include<stdio.h>
 2 #include<pthread.h>
 3
 4 void *foo(void *arg){
 5   int *myid = (int *) arg;
 6   printf("Hello from thread %d\n", *myid);
 7   return NULL;
 8 }
 9
10 int main(){
11   pthread_t tid[4];
12   int i;
13
14   for(i=0; i<4; i++)
15     pthread_create(&tid[i], NULL, foo, &i);
16
17   for(i=0; i<4; i++)
18     pthread_join(tid[i], NULL);
19
20   return 0;
21 }
```

We might expect that the program will print all the four values of `i`, but when the program is executed, we see the following incorrect result containing repetitions:

```
Hello from thread 1
Hello from thread 3
Hello from thread 3
Hello from thread 3
```

What causes this behavior? Explain your answer. **[10 marks]**

(b) `[Continuation of Question 2a above]` Rectify *only* the `main()` function such that the concurrent peer threads print unique values, i.e., the first thread prints 0, the second thread prints 1, the third thread prints 2 and the final thread prints 3. We don't expect the threads will print "in order" (we expect that they just print the correct value per thread). Explain your answer. **[10 marks]**

Question 3

(a) Describe how paging works. **[5 marks]**

(b) Can you use a buffer in userspace as a target for memory transfers using DMA from peripheral devices? Justify your answer. **[5 marks]**

(c) A debugger makes it possible to observe and control the execution of some process and change its memory and registers. How would you use paging and/or segmentation to support a debugger? **[5 marks]**

(d) A laboratory is used for teaching first-year programming as well as running CPU-intensive processes for research in the background. Before upgrading the memory-intensive IDE which is used for programming, the CPU was normally in use for nearly 100% of the time, and the response time was short. After the upgrade the response time has increased dramatically, and throughput has been drastically reduced. Give a possible cause for this behaviour and suggest a remedy which does not involve additional hardware. **[5 marks]**

Question 4

(a) What is a microkernel? **[6 marks]**

(b) Why is an efficient implementation of inter-process communication critical for the efficiency of microkernels? **[6 marks]**

(c) You are asked to write a device driver in a microkernel system for a digital camera connected to the usb-bus, which contains a tape to store the videos. The device driver has to fulfil two functions. Firstly, it has to access the data which is on the tape in the digital camera on a FAT-filesystem, and secondly it has to control the movements of the tape (move it forward, backwards and stop it). Which parts of the device driver must be implemented in the microkernel, and which parts may be implemented as services in user mode? Justify your answer. **[8 marks]**

End of Paper

Do not complete the attendance slip, fill in the front of the answer book or turn over the question paper until you are told to do so

Important Reminders

- Coats/outwear should be placed in the designated area.
- Unauthorised materials (e.g. notes or Tippex) must be placed in the designated area.
- Check that you do not have any unauthorised materials with you (e.g. in your pockets, pencil case).
- Mobile phones and smart watches **must** be switched off and placed in the designated area or under your desk. They must not be left on your person or in your pockets.
- You are not permitted to use a mobile phone as a clock. If you have difficulty seeing a clock, please alert an Invigilator.
- You are not permitted to have writing on your hand, arm or other body part.
- Check that you do not have writing on your hand, arm or other body part – if you do, you must inform an Invigilator immediately
- Alert an Invigilator immediately if you find any unauthorised item upon you during the examination.

Any students found with non-permitted items upon their person during the examination, or who fail to comply with Examination rules may be subject to Student Conduct procedures.